

EVALUATION OF n + 186W CROSS SECTIONS FOR THE ENERGY
RANGE 1.0E-11 to 150 MeV

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This evaluation provides a complete representation of the nuclear data needed for transport, damage, heating, radioactivity, and shielding applications over the incident neutron energy range from 1.0E-11 to 150 MeV. The discussion here is divided into the region below and above 20 MeV.

INCIDENT NEUTRON ENERGIES < 20 MeV

Below 20 MeV the evaluation is based completely on the ENDF/B-VI.0 (Release 0) evaluation, which was carried over from ENDF/B-V.2 [Ar80]. The following modifications were made to the ENDF/B-VI.0 evaluation:

1. The derived MF=3 files for MT=203 and 207 were removed.

INCIDENT NEUTRON ENERGIES > 20 MeV

The evaluation above 20 MeV utilizes MF=6, MT=5 to represent all reaction data. Production cross sections and emission spectra are given for neutrons, protons, deuterons, tritons, alpha particles, gamma rays, and all residual nuclides produced ($A>5$) in the reaction chains. To summarize, the ENDF sections with non-zero data above $E_n = 20$ MeV are:

MF=3	MT= 1	Total Cross Section
	MT= 2	Elastic Scattering Cross Section
	MT= 3	Nonelastic Cross Section
	MT= 5	Sum of Binary (n,n') and (n,x) Reactions
MF=4	MT= 2	Elastic Angular Distributions
MF=6	MT= 5	Production Cross Sections and Energy-Angle Distributions for Emission Neutrons, Protons, Deuterons, and Alphas; and Angle-Integrated Spectra for Gamma Rays and Residual Nuclei That Are Stable Against Particle Emission

The evaluation is based on nuclear model calculations that have been benchmarked to experimental data, especially for n + W, n + Ta, p + Ta, and p + W reactions (Ch96a). We use the GNASH code system (Yo92), which utilizes Hauser-Feshbach statistical, preequilibrium and direct-reaction theories. Coupled-channels and spherical optical model calculations are used to obtain particle transmission coefficients for the Hauser-Feshbach calculations, as well as for the elastic neutron angular distributions.

Cross sections and spectra for producing individual residual nuclei are included for reactions that exceed a cross section of approximately 1 nb at any energy. The energy-angle-correlations for all outgoing particles are based on Kalbach systematics (Ka88).

Because of the almost total absence of W data, the neutron total cross section above 20 MeV is based on the measurements of

Finlay et al. (Fi93) of the n + Ta total cross section. A coupled-channels neutron optical model potential based on earlier work to 100 MeV (Yo90) is utilized to 80 MeV, and the global spherical optical model potential of Madland (Ma88) is used at higher energies. For protons, the Beccetti-Greenlees potential (Be69) is utilized below 50 MeV, and the Madland Semmering potential (Ma88) at higher energies. The Perey potential (Pe63) is used for deuterons, and the Beccetti-Greenlees potential (Be71) for tritons. The ECIS79 code (Ra72) was used for the coupled-channels optical model calculations, and the SCAT2 code (Be92) was utilized for the spherical optical model calculations. Minor normalizations were made to the reaction cross sections and transmission coefficients to produce agreement with the (sparse) measurements for W and values inferred from systematics of proton and neutron reaction cross sections from measurements on other targets.

A model was developed to calculate the energy distributions of all recoil nuclei in the GNASH calculations (Ch96b). The recoil energy distributions are represented in the laboratory system in MT=5, MF=6, and are given as isotropic in the lab system. Note that all other data in MT=5, MF=6 are given in the center-of-mass system. This method of representation requires a modification of the original ENDF-6 format.

Preequilibrium corrections were performed in the course of the GNASH calculations using the exciton model of Kalbach (Ka77, Ka85), validated by comparison with calculations using Feshbach, Kerman, Koonin (FKK) theory [Ch93]. Discrete level data from nuclear data sheets were matched to continuum level densities using the formulation of Ignatyuk (Ig75) and pairing and shell parameters from the Cook (Co67) analysis. Neutron and charged-particle transmission coefficients were obtained from the optical potentials, as discussed above. Gamma-ray transmission coefficients were calculated using the Kopecky-Uhl model (Ko90).

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74186 = TARGET 1000Z+A (if A=0 then elemental)

1 = PROJECTILE 1000Z+A

Nonelastic, elastic, and Production cross sections for A<5 projectiles in barns:

Energy	nonelas	elastic	neutron	proton	deuteron	triton	helium3	alpha	gamma
2.000E+01	2.446E+00	2.938E+00	5.851E+00	1.826E-02	3.242E-03	3.612E-04	0.000E+00	1.020E-03	1.080E+01
2.200E+01	2.439E+00	2.791E+00	6.004E+00	2.947E-02	5.249E-03	6.553E-04	0.000E+00	1.390E-03	1.186E+01
2.400E+01	2.435E+00	2.631E+00	6.273E+00	4.372E-02	7.344E-03	9.764E-04	0.000E+00	1.743E-03	1.220E+01
2.600E+01	2.424E+00	2.459E+00	6.672E+00	6.100E-02	9.479E-03	1.301E-03	0.000E+00	2.073E-03	1.159E+01
2.800E+01	2.411E+00	2.274E+00	6.972E+00	8.143E-02	1.161E-02	1.596E-03	0.000E+00	2.362E-03	1.116E+01
3.000E+01	2.394E+00	2.116E+00	7.155E+00	1.042E-01	1.376E-02	1.873E-03	0.000E+00	2.630E-03	1.116E+01
3.500E+01	2.344E+00	1.866E+00	7.573E+00	1.671E-01	1.853E-02	2.394E-03	0.000E+00	3.183E-03	1.096E+01
4.000E+01	2.292E+00	1.764E+00	7.886E+00	2.291E-01	2.227E-02	2.718E-03	0.000E+00	3.641E-03	1.107E+01
4.500E+01	2.238E+00	1.808E+00	8.101E+00	2.894E-01	2.490E-02	2.939E-03	0.000E+00	4.050E-03	1.097E+01
5.000E+01	2.183E+00	1.917E+00	8.309E+00	3.445E-01	2.689E-02	3.074E-03	0.000E+00	4.449E-03	1.078E+01
5.500E+01	2.129E+00	2.091E+00	8.462E+00	3.944E-01	2.842E-02	3.181E-03	0.000E+00	4.869E-03	1.069E+01
6.000E+01	2.081E+00	2.256E+00	8.621E+00	4.412E-01	2.932E-02	3.255E-03	0.000E+00	5.349E-03	1.063E+01
6.500E+01	2.048E+00	2.382E+00	8.799E+00	4.873E-01	3.050E-02	3.347E-03	0.000E+00	5.945E-03	1.060E+01
7.000E+01	2.021E+00	2.479E+00	8.882E+00	5.310E-01	3.157E-02	3.432E-03	0.000E+00	6.697E-03	9.030E+00
7.500E+01	1.997E+00	2.530E+00	9.097E+00	5.705E-01	3.225E-02	3.524E-03	0.000E+00	7.605E-03	8.272E+00
8.000E+01	1.971E+00	2.554E+00	9.305E+00	6.001E-01	3.254E-02	3.659E-03	0.000E+00	8.816E-03	8.865E+00
8.500E+01	1.941E+00	2.577E+00	9.491E+00	6.240E-01	3.295E-02	3.885E-03	0.000E+00	1.021E-02	8.729E+00
9.000E+01	1.910E+00	2.558E+00	9.631E+00	6.461E-01	3.346E-02	4.171E-03	0.000E+00	1.174E-02	8.594E+00
9.500E+01	1.874E+00	2.498E+00	9.760E+00	6.641E-01	3.354E-02	4.471E-03	0.000E+00	1.351E-02	8.406E+00
1.000E+02	1.837E+00	2.435E+00	9.831E+00	6.799E-01	3.357E-02	4.810E-03	0.000E+00	1.538E-02	8.342E+00
1.100E+02	1.774E+00	2.310E+00	9.988E+00	7.086E-01	3.351E-02	5.675E-03	0.000E+00	1.975E-02	8.008E+00
1.200E+02	1.721E+00	2.119E+00	1.013E-01	7.347E-01	3.334E-02	6.788E-03	0.000E+00	2.482E-02	7.767E+00
1.300E+02	1.678E+00	1.962E+00	1.028E+01	7.599E-01	3.315E-02	8.153E-03	0.000E+00	3.064E-02	7.440E+00
1.400E+02	1.645E+00	1.788E+00	1.046E+01	7.868E-01	3.288E-02	9.749E-03	0.000E+00	3.723E-02	7.356E+00
1.500E+02	1.624E+00	1.646E+00	1.064E+01	8.176E-01	3.285E-02	1.150E-02	0.000E+00	4.435E-02	7.105E+00

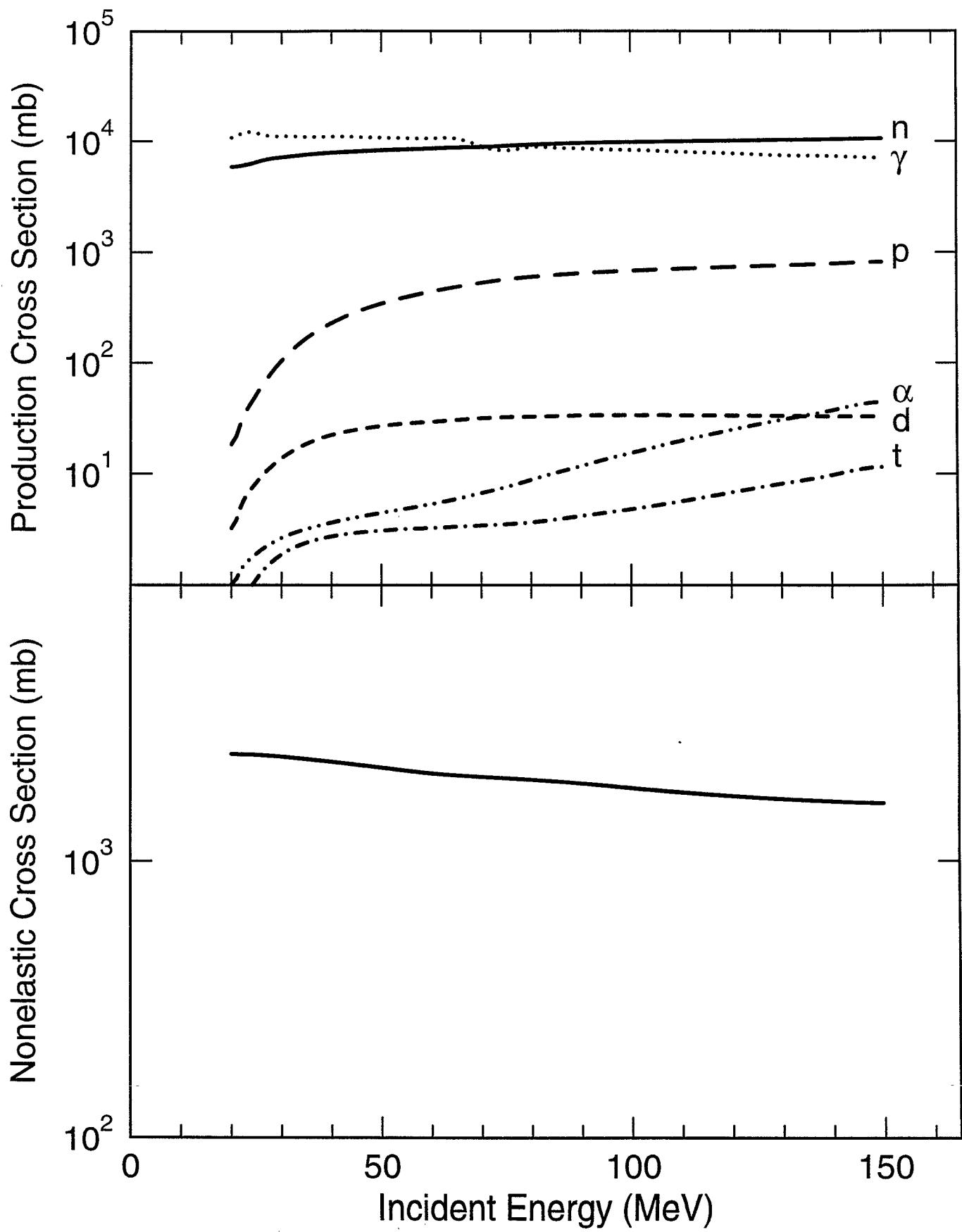
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1 = PROJECTILE 1000Z+A

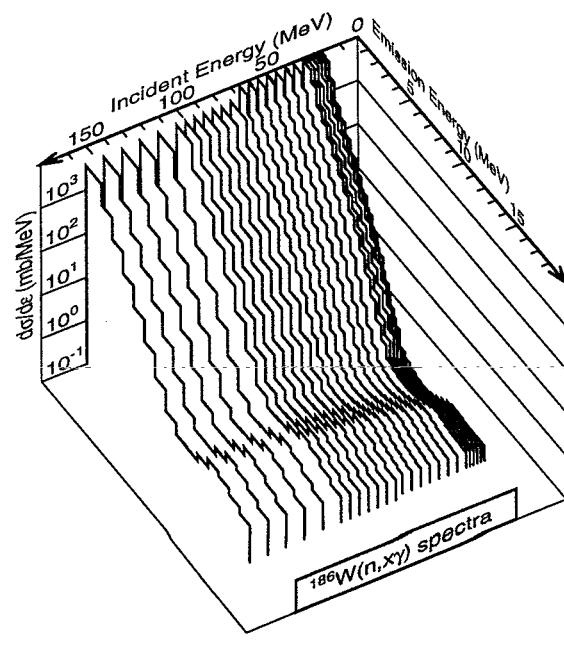
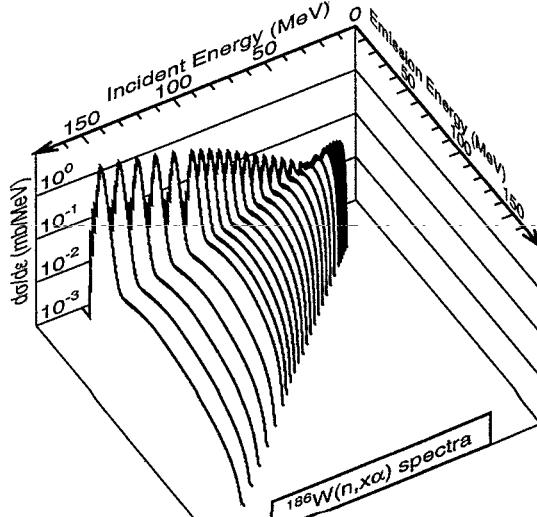
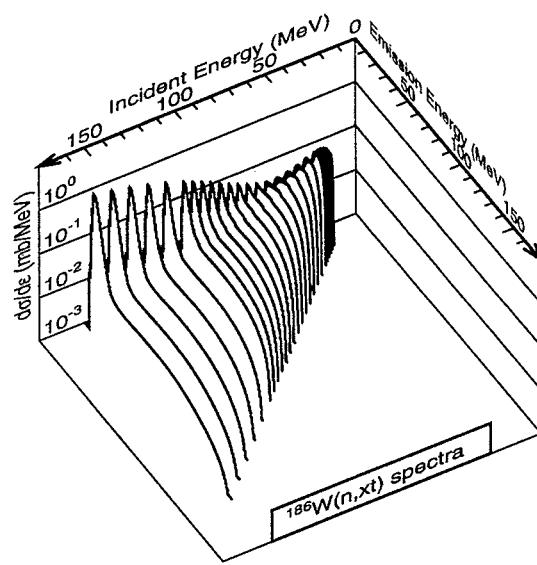
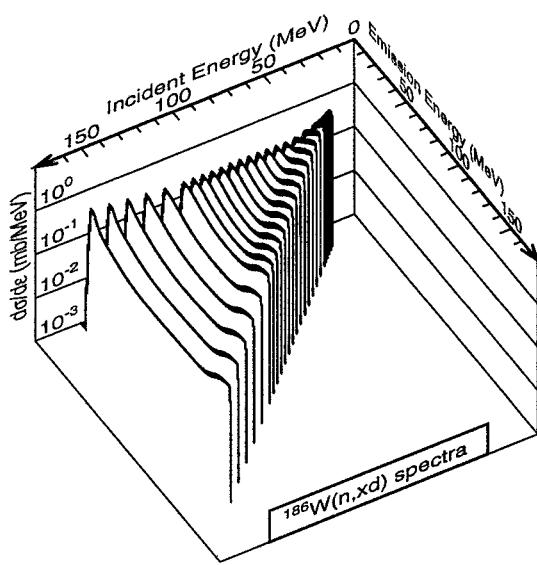
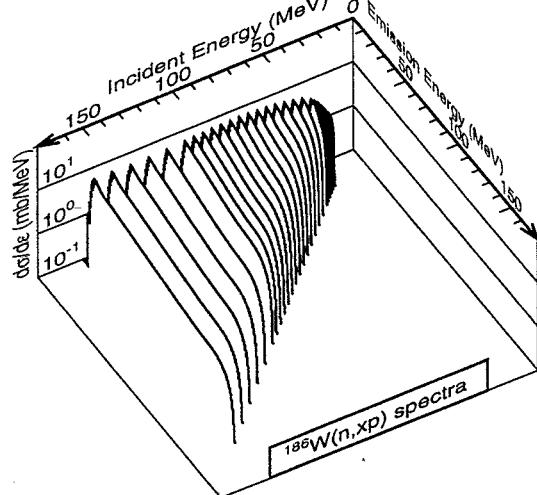
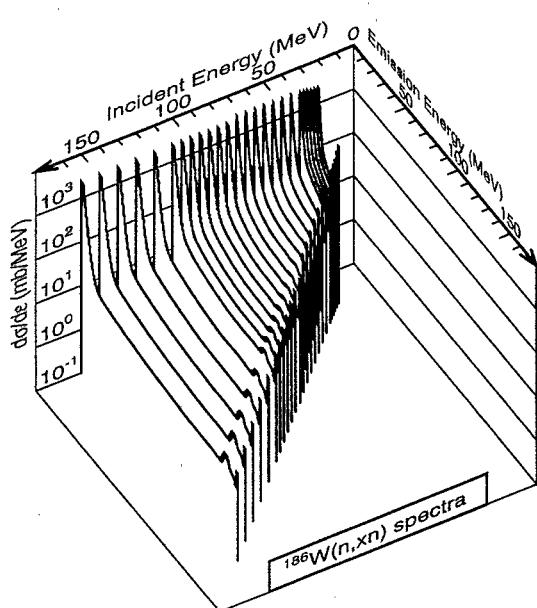
Kerma coefficients in units of f.Gy.m^2:

Energy	proton	deuteron	triton	helium3	alpha	non-rec	elas-rec	TOTAL
2.000E+01	1.147E-02	1.956E-03	1.971E-04	0.000E+00	1.101E-03	1.634E-02	2.459E-03	3.352E-02
2.200E+01	1.984E-02	3.529E-03	3.940E-04	0.000E+00	1.570E-03	1.767E-02	2.201E-03	4.520E-02
2.400E+01	3.116E-02	5.426E-03	6.392E-04	0.000E+00	2.053E-03	1.904E-02	2.278E-03	6.060E-02
2.600E+01	4.573E-02	7.615E-03	9.192E-04	0.000E+00	2.537E-03	2.036E-02	2.396E-03	7.955E-02
2.800E+01	6.405E-02	1.006E-02	1.208E-03	0.000E+00	2.997E-03	2.158E-02	2.532E-03	1.024E-01
3.000E+01	8.601E-02	1.279E-02	1.512E-03	0.000E+00	3.452E-03	2.266E-02	2.693E-03	1.291E-01
3.500E+01	1.549E-01	2.015E-02	2.206E-03	0.000E+00	4.503E-03	2.486E-02	3.078E-03	2.097E-01
4.000E+01	2.366E-01	2.784E-02	2.792E-03	0.000E+00	5.470E-03	2.695E-02	3.356E-03	3.030E-01
4.500E+01	3.292E-01	3.505E-02	3.320E-03	0.000E+00	6.385E-03	2.866E-02	3.515E-03	4.061E-01
5.000E+01	4.257E-01	4.197E-02	3.769E-03	0.000E+00	7.271E-03	3.006E-02	3.541E-03	5.123E-01
5.500E+01	5.244E-01	4.851E-02	4.188E-03	0.000E+00	8.163E-03	3.115E-02	3.554E-03	6.200E-01
6.000E+01	6.267E-01	5.387E-02	4.551E-03	0.000E+00	9.095E-03	3.213E-02	3.509E-03	7.298E-01
6.500E+01	7.352E-01	6.014E-02	4.919E-03	0.000E+00	1.015E-02	3.311E-02	3.394E-03	8.469E-01
7.000E+01	8.479E-01	6.648E-02	5.237E-03	0.000E+00	1.133E-02	3.428E-02	3.277E-03	9.685E-01
7.500E+01	9.611E-01	7.200E-02	5.513E-03	0.000E+00	1.262E-02	3.514E-02	3.089E-03	1.089E+00
8.000E+01	1.064E+00	7.668E-02	5.761E-03	0.000E+00	1.413E-02	3.590E-02	2.870E-03	1.200E+00
8.500E+01	1.163E+00	8.173E-02	6.112E-03	0.000E+00	1.578E-02	3.650E-02	1.490E-03	1.304E+00
9.000E+01	1.262E+00	8.714E-02	6.524E-03	0.000E+00	1.756E-02	3.685E-02	1.456E-03	1.411E+00
9.500E+01	1.356E+00	9.126E-02	6.838E-03	0.000E+00	1.952E-02	3.707E-02	1.407E-03	1.512E+00
1.000E+02	1.449E+00	9.516E-02	7.162E-03	0.000E+00	2.154E-02	3.708E-02	1.364E-03	1.611E+00
1.100E+02	1.635E+00	1.022E-01	7.864E-03	0.000E+00	2.620E-02	3.716E-02	1.292E-03	1.810E+00
1.200E+02	1.824E+00	1.079E-01	8.647E-03	0.000E+00	3.158E-02	3.708E-02	1.195E-03	2.011E+00
1.300E+02	2.018E+00	1.126E-01	9.542E-03	0.000E+00	3.776E-02	3.821E-02	1.127E-03	2.218E+00
1.400E+02	2.222E+00	1.157E-01	1.055E-02	0.000E+00	4.475E-02	4.019E-02	1.060E-03	2.435E+00
1.500E+02	2.444E+00	1.192E-01	1.164E-02	0.000E+00	5.234E-02	4.227E-02	1.029E-03	2.670E+00

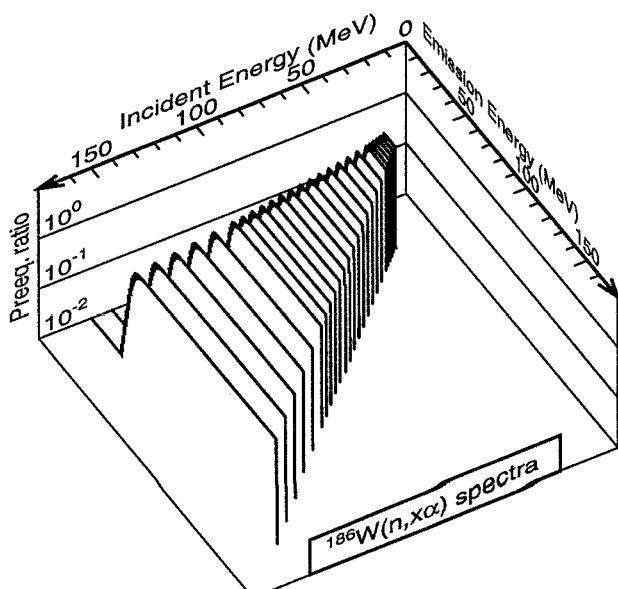
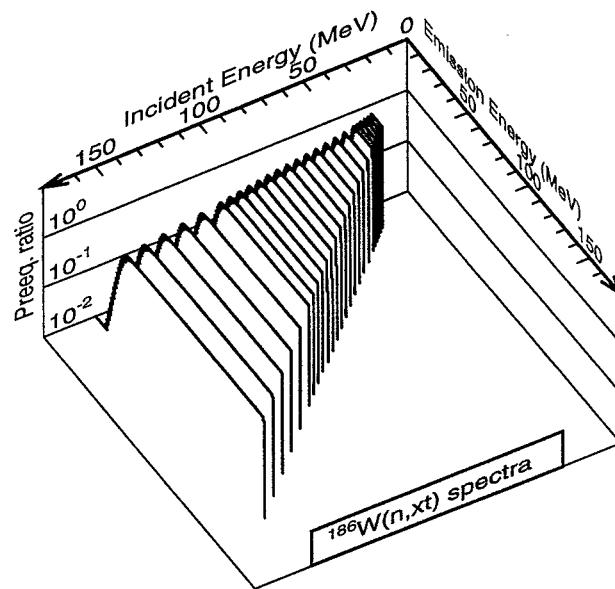
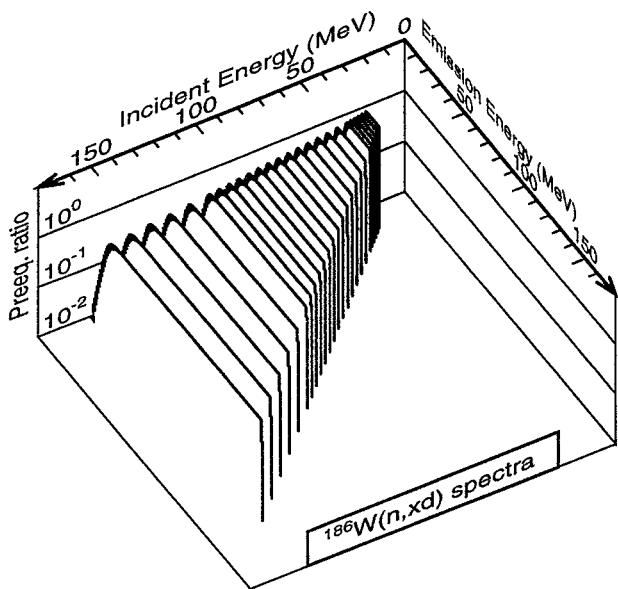
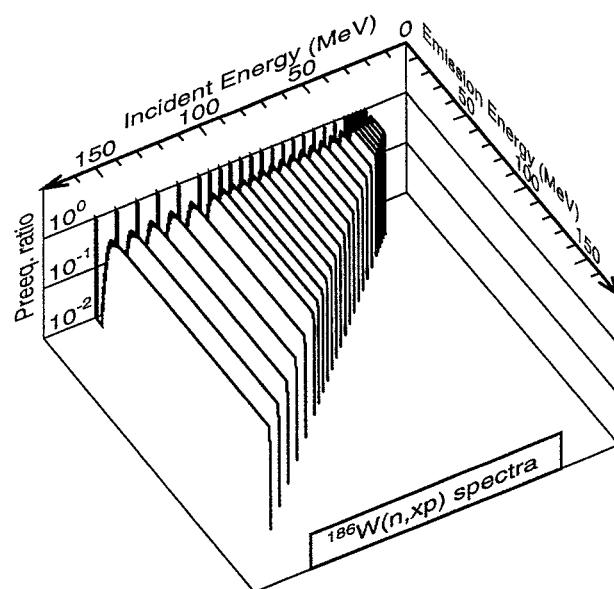
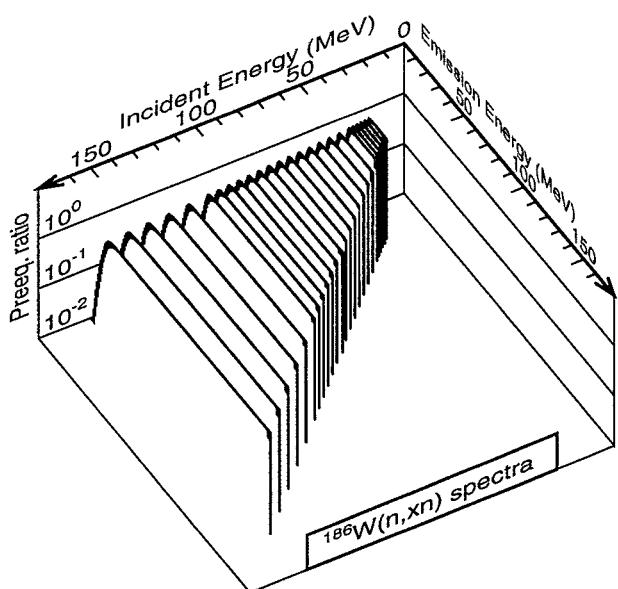
$n + {}^{186}\text{W}$ nonelastic and production cross sections



$n + ^{186}\text{W}$ angle-integrated emission spectra

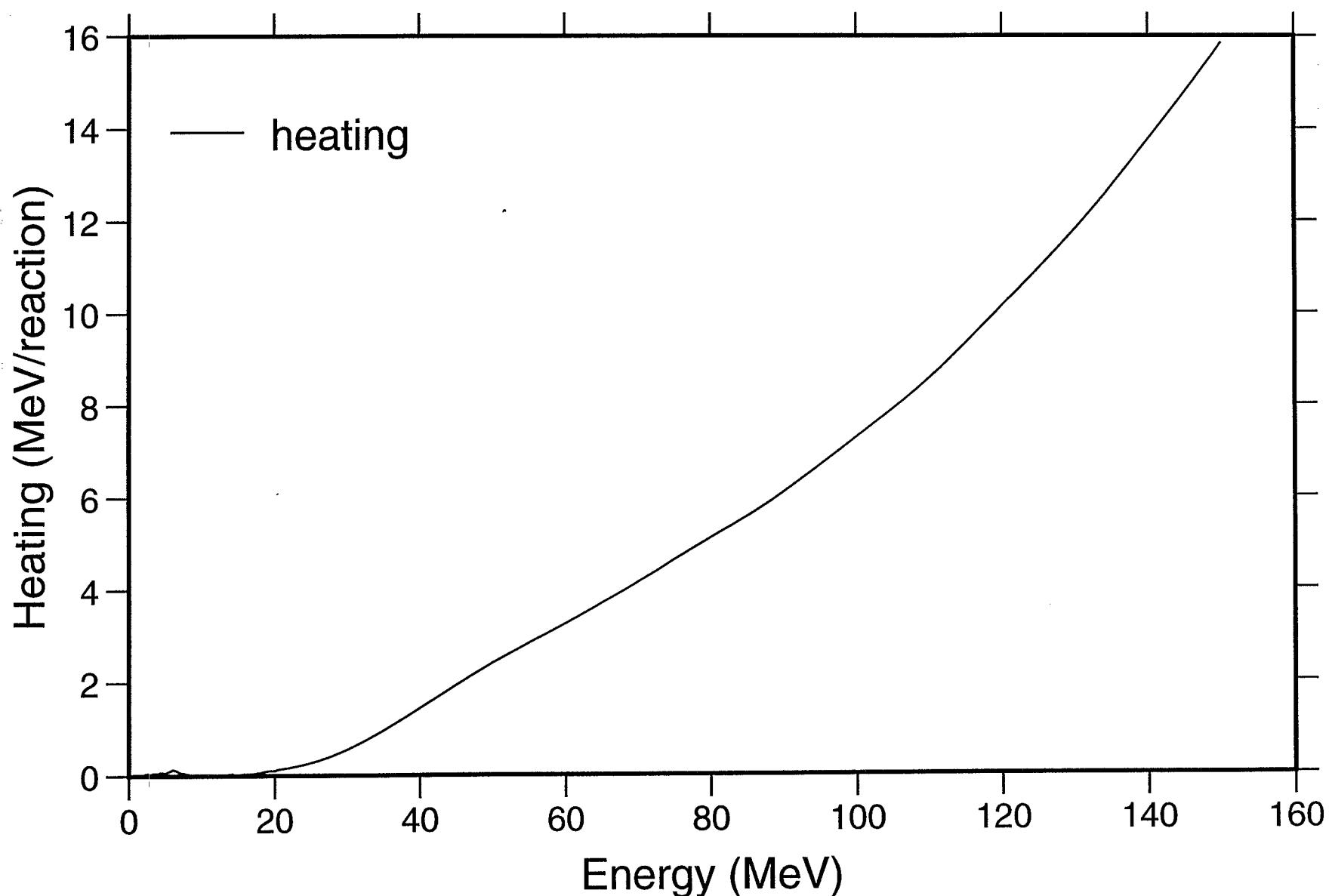


$n + {}^{186}\text{W}$ Kalbach preequilibrium ratios



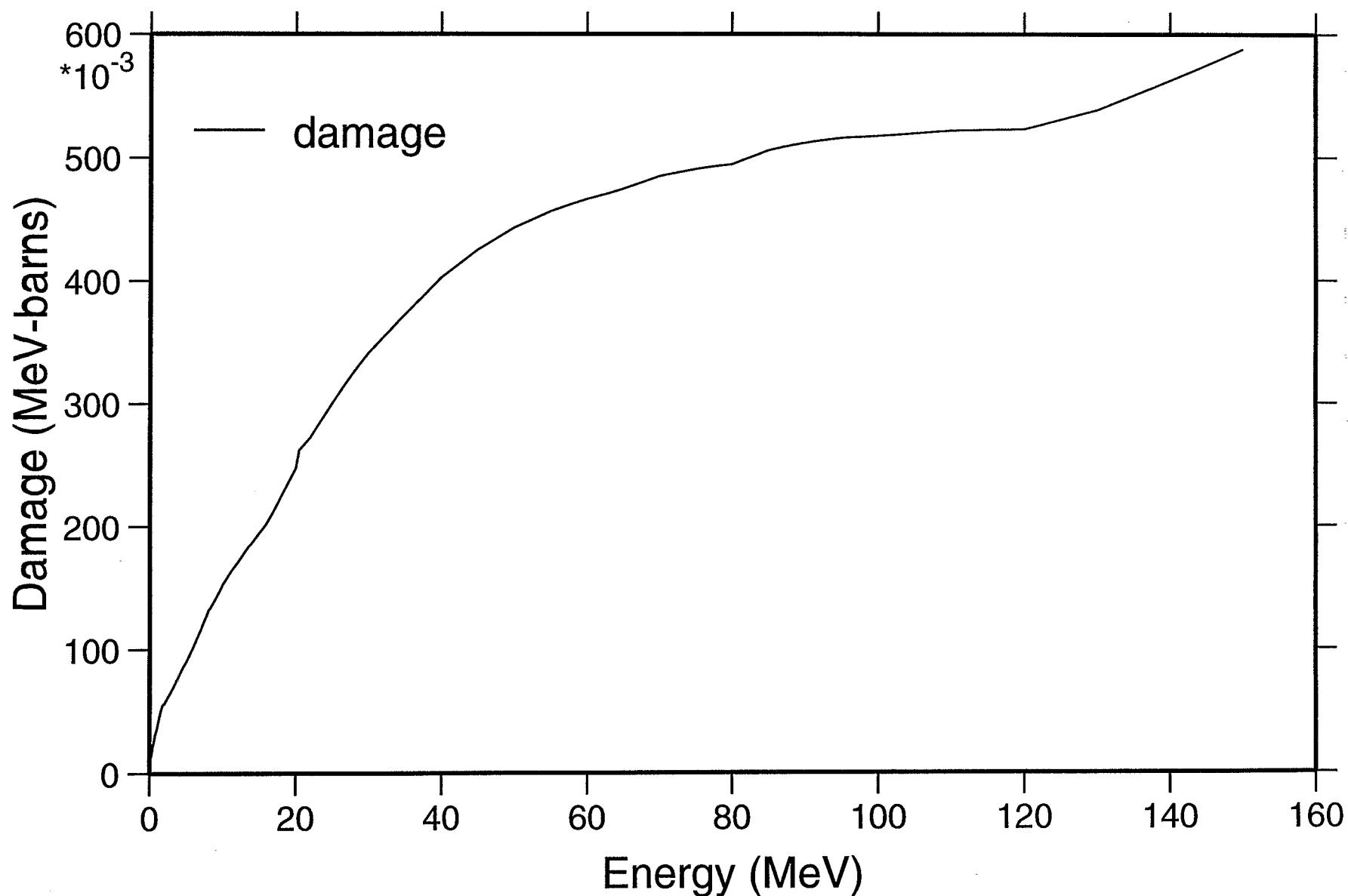
74-W-186 APT LA150 NJOY 97.18 MCNPX

Heating



74-W-186 APT LA150 NJOY 97.18 MCNPX

Damage



74-W-186 APT LA150 NJOY 97.18 MCNPX
angular distribution for elastic

